CLAIMS

1. An optical signal transmitter for applying frequency modulation to amplitude-modulated electric signals that have undergone frequency division multiplexing to optically transmit the electric signals, the optical signal transmitter comprising:

a distribution circuit for distributing the electric signals into a plurality of signal parts and outputting the signal parts;

a plurality of frequency modulation means for applying frequency modulation to each output of the distribution circuit and emitting each output, the plurality of frequency modulation means being substantially equal to each other in frequency deviation and in intermediate frequency and being substantially identical in the phase of each output;

a multiplexing means for multiplexing outputs of the plurality of frequency modulation means and outputting multiplexed outputs; and

a transmitting circuit for outputting optical signals subjected to intensity modulation by the output of the multiplexing means to an optical transmission path.

2. An optical signal transmitter according to Claim 1, wherein the distribution circuit distributes and outputs the electric signals into N signal parts (N is an integer which is two or greater),

the plurality of frequency modulation means are N FM batch conversion circuits from which each output of the distribution circuit is subjected to frequency modulation to output, and

the multiplexing means is an optical multiplexing circuit for multiplexing outputs of the N FM batch conversion circuits and outputting multiplexed outputs,

wherein the N FM batch conversion circuits are set to be substantially equal to each other in frequency deviation and in intermediate frequency and to be substantially identical in the phase of each output.

3. An optical signal transmitter according to Claim 2, wherein each of the FM batch conversion circuits comprises:

an optical frequency modulation portion for outputting a frequency-modulated optical signal applied frequency modulation to the electric signals input from the distribution circuit as a modulated input;

an optical frequency local oscillation portion for outputting an optical local oscillation signal having a frequency apart from an optical center frequency of the frequency-modulated optical signal output from the optical frequency modulation portion by a frequency substantially equal to an intermediate frequency;

an optical multiplexer for multiplexing the frequency-modulated optical signal and the optical local oscillation signal together and outputting a multiplexed

optical signal; and

an optical detector for applying heterodyne detection to the multiplexed optical signal output from the optical multiplexer and outputting an electric signal having a frequency equal to a difference between an optical frequency of the frequency-modulated optical signal and an optical frequency of the optical local oscillation signal.

4. An optical signal transmitter according to Claim 2, wherein each of the FM batch conversion circuits comprises:

a differential distributor for distributing the electric signal output from the distribution circuit into two electric signals in which phases have been inverted;

a first optical frequency modulation portion for outputting a first frequency-modulated optical signal applied frequency modulation to one of the two electric signals input from the differential distributor as a modulated input;

a second optical frequency modulation portion for outputting a second frequency-modulated optical signal applied frequency modulation to the other one of the two electric signals input form the differential distributor as a modulated signal, the second frequency-modulated optical signal having an optical frequency apart from an optical center frequency of the first frequency-modulated optical signal by a frequency substantially equal to an intermediate frequency;

an optical multiplexer for multiplexing the first frequency-modulated optical signal and the second frequency-modulated optical signal and outputting a multiplexed optical signal; and

an optical detector for applying heterodyne detection to the multiplexed optical signal output from the optical multiplexer and outputting an electric signal having a frequency equal to a difference between an optical frequency of the first frequency-modulated optical signal and an optical frequency of the second frequency-modulated optical signal.

5. An optical signal transmitter according to Claim 2, wherein each of the FM batch conversion circuits comprises a voltage-controlled oscillator for converting the electric signal output from the distribution circuit into a signal having a frequency corresponding to a voltage thereof with an intermediate frequency as a center frequency and outputting a converted signal.

6. An optical signal transmitter according to Claim 2, wherein each of the FM batch conversion circuits comprises:

a differential distributor for distributing the electric signal output from the distribution circuit into two electric signals in which phases have been inverted;

a first voltage-controlled oscillator for outputting a first frequency-modulated optical signal obtained by

converting one of the two electric signals emitted from the differential distributor so as to have a frequency corresponding to a voltage thereof;

a second voltage-controlled oscillator for outputting a second frequency-modulated optical signal obtained by converting the other one of the two electric signals emitted from the differential distributor so as to have a frequency corresponding to a voltage thereof, a center frequency of the second frequency-modulated optical signal being apart from a center frequency of the first frequency-modulated signal by a frequency substantially equal to an intermediate frequency;

a mixer for mixing the first frequency-modulated signal output from the first voltage-controlled oscillator and the second frequency-modulated signal output from the second voltage-controlled oscillator together; and

a low-pass filter for allowing the electric signal output from the mixer to pass through, the electric signal having a frequency equal to a difference between a frequency of the first frequency-modulated signal and a frequency of the second frequency-modulated signal.

7. An optical signal transmitter according to Claim 1, wherein the distribution circuit distributes the electric signal into two signals (N=2) and outputs these signals, the frequency modulation means includes:

a first optical frequency modulation portion for

outputting a first frequency-modulated optical signal applied frequency modulation to one of the two electric signals input from the distribution circuit as a modulated input;

a first optical frequency local oscillation portion for outputting a first optical local oscillation signal having an optical frequency apart from an optical center frequency of the first frequency-modulated optical signal output from the first optical frequency modulation portion by a frequency substantially equal to an intermediate frequency;

a first optical multiplexer for multiplexing the first frequency-modulated optical signal and the first optical local oscillation signal so as to become identical in polarization direction and outputting a first multiplexed optical signal;

a second optical frequency modulation portion for outputting a second frequency-modulated optical signal applied frequency modulation to the other one of the two electric signals input from the distribution circuit as a modulated input;

a second optical frequency local oscillation portion for outputting a second optical local oscillation signal having an optical frequency apart from an optical center frequency of the second frequency-modulated optical signal output from the second optical frequency modulation portion by a frequency substantially equal to the intermediate

frequency; and

a second optical multiplexer for multiplexing the second frequency-modulated optical signal and the second optical local oscillation signal together so as to become identical in polarization direction and outputting a second multiplexed optical signal,

the multiplexing means is a third optical multiplexer for multiplexing the first multiplexed optical signal output from the first optical multiplexer and the second multiplexed optical signal output from the second optical multiplexer so that a polarization direction of the first multiplexed optical signal becomes perpendicular to a polarization direction of the second multiplexed optical signal and outputting a third muptiplexed optical signal,

the optical signal transmitter further comprising:

an optical detector for applying heterodyne detection to the third multiplexed optical signal output from the third optical multiplexer and outputting an electric signal having a frequency equal to a difference between an optical frequency of the first frequency-modulated optical signal and an optical frequency of the first optical local oscillation signal and an electric signal having a frequency equal to a difference between an optical frequency of the second frequency-modulated optical signal and an optical frequency of the second optical local oscillation signal; and

a transmitting circuit for outputting an optical

signal subjected to intensity modulation by an output of the optical detector to an optical transmission path;

wherein the first optical frequency modulation portion and the second optical frequency modulation portion are set to be substantially equal to each other in frequency deviation, wherein a phase of an electric signal obtained by subjecting the first multiplexed optical signal to heterodyne detection in the optical detector is set to be substantially identical to a phase of an electric signal obtained by subjecting the second multiplexed optical signal to heterodyne detection in the optical detector.

8. An optical signal transmitter according to Claim 1, wherein the distribution circuit distributes the electric signal into two electric signals (N=2) and outputs these electric signals, the frequency modulation means includes:

a first differential distributor for distributing one of the two electric signals output from the distribution circuit into two electric signals in which phases have been inverted;

a first optical frequency modulation portion for outputting a first frequency-modulated optical signal applied frequency modulation to one output of the first differential distributor as a modulated input;

a second optical frequency modulation portion for receiving the other output of the first differential distributor as a modulated input and outputting a second

frequency-modulated optical signal, the second frequency-modulated optical signal having an optical frequency apart from an optical center frequency of the first frequency-modulated optical signal output from the first optical frequency modulation portion by a frequency substantially equal to an intermediate frequency;

a first optical multiplexer for multiplexing the first frequency-modulated optical signal and the second frequency-modulated optical signal together so as to become identical in polarization direction and outputting a first multiplexed optical signal;

a second differential distributor for distributing the other output of the distribution circuit into two electric signals in which phases have been inverted;

a third optical frequency modulation portion for outputting a third frequency-modulated optical signal receiving one output of the second differential distributor as a modulated input to apply frequency modulation to the one output of the second differential distributor;

a fourth optical frequency modulation portion for receiving the other one of the two electric signals output from the second differential distributor as a modulated input and outputting a fourth frequency-modulated optical signal, the fourth frequency-modulated optical signal having an optical frequency apart from an optical center frequency of the third frequency-modulated optical signal output from the third optical frequency modulation portion

by a frequency substantially equal to the intermediate frequency; and

a second optical multiplexer for multiplexing the third frequency-modulated optical signal and the fourth frequency-modulated optical signal together so as to become identical in polarization direction and outputting a second multiplexed optical signal,

the multiplexing means is a third optical multiplexing for multiplexing the first multiplexed optical signal output from the first optical multiplexer and the second multiplexed optical signal output from the second optical multiplexer so that a polarization direction of the first multiplexed optical signal becomes perpendicular to a polarization direction of the second multiplexed optical signal and outputting a third multiplexed optical signal,

the optical signal transmitter further comprising:

an optical detector for applying heterodyne detection to the third multiplexed optical signal output from the third optical multiplexer and outputting an electric signal having a frequency equal to a difference between an optical frequency of the first frequency-modulated optical signal and an optical frequency of the second frequency-modulated optical signal and an electric signal having a frequency equal to a difference between an optical frequency of the third frequency-modulated optical signal and an optical frequency of the fourth frequency-modulated optical signal; and

a transmitting circuit for outputting an optical signal subjected to intensity modulation by an output of the optical detector to an optical transmission path;

wherein the first frequency modulation portion, second frequency modulation portion, third frequency modulation portion, and fourth optical frequency modulation portion are set to be substantially equal to each other in frequency deviation, and a phase of an electric signal obtained by subjecting the first multiplexed optical signal to heterodyne detection in the optical detector is set to be substantially identical to a phase of an electric signal obtained by subjecting the second multiplexed optical signal to heterodyne detection in the optical detector.

9. An optical signal transmitter according to Claim 1, wherein the distribution circuit distributes the electric signal into N signals (N is an integer which is two or greater) and outputs these signals, the frequency modulation means includes N optical frequency modulation multiplexing circuits for multiplexing a frequency-modulated optical signal applied frequency modulation to each output input from the distribution circuits as a modulated input and an optical local oscillation signal having an optical frequency apart from an optical center frequency of the frequency-modulated optical signal by a frequency substantially equal to an intermediate frequency together, and outputting a multiplexed signal,

the multiplexing means is an optical multiplexing circuit for multiplexing outputs of the N optical frequency modulation multiplexing circuits and outputting a multiplexed signal,

the optical signal transmitter further comprising:

an optical detection circuit for applying heterodyne detection to an output of the optical multiplexing circuit and outputting an electric signal having a frequency equal to a difference between an optical frequency of the frequency-modulated optical signal and an optical frequency of the optical local oscillation signal; and

a transmitting circuit for outputting an optical signal subjected to intensity modulation by an output of the optical detection circuit to an optical transmission path;

wherein the N optical frequency modulation multiplexing circuits are set to be substantially equal to each other in frequency deviation and to be substantially identical to each other in intermediate frequency and in the phase of each of the N superposed electric signals obtained by applying heterodyne detection to multiplexed optical signals output from the N optical frequency modulation multiplexing circuits in the optical detection circuit.

10. An optical signal transmitter according to Claim 1, wherein the distribution circuit distributes the electric

signal into N signals (N is an integer which is two or greater) and outputs these signals, the frequency modulation means includes N differential optical frequency modulation multiplexing circuits for distributing each output of the distribution circuit into two electric signals in which phases have been inverted, multiplexing a first frequency-modulated optical signal applied frequency modulation to one of the two electric signals input from the distribution circuit as a modulated input and a second frequency-modulated optical signal having an optical frequency apart from an optical center frequency of the first frequency-modulated optical signal by a frequency substantially equal to an intermediate frequency, the second frequency-modulated optical signal applied frequency modulation to the other one of the two electric signals input from the distribution circuit as a modulated input, and outputting a multiplexed signal,

the multiplexing means is an optical multiplexing circuit for multiplexing outputs of the N differential optical frequency modulation multiplexing circuits and outputting a multiplexed signal,

the optical signal transmitter further comprising:

an optical detection circuit for applying heterodyne detection to an output of the optical multiplexing circuit and outputting an electric signal having a frequency equal to a difference between an optical frequency of the first frequency-modulated optical signal and an optical frequency

of the second frequency-modulated optical signal; and

a transmitting circuit for outputting an optical signal subjected to intensity modulation by an output of the optical detection circuit to an optical transmission path;

wherein the N differential optical frequency modulation multiplexing circuits are set to be substantially equal to each other in frequency deviation and to be substantially identical to each other in intermediate frequency and in the phase of each of the N superposed electric signals obtained by applying heterodyne detection to multiplexed optical signals output from the N differential optical frequency modulation multiplexing circuits in the optical detection circuit.

11. An optical signal transmission system comprising:

the optical signal transmitter according to any one of Claims 1 to 10, and

an optical signal receiver including a photoelectric conversion means connected to the optical signal transmitter via an optical transmission path and a frequency demodulation means for demodulating an output of the photoelectric conversion means.